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Enhancement of the Transmission Loss of Panel Structures Through the Application of Segmented, Resonant Foam Attachments

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ENHANCEMENT OF THE TRANSMISSION LOSS OF PANEL STRUCTURES THROUGH THE APPLICATION OF SEGMENTED, RESONANT FOAM ATTACHMENTS

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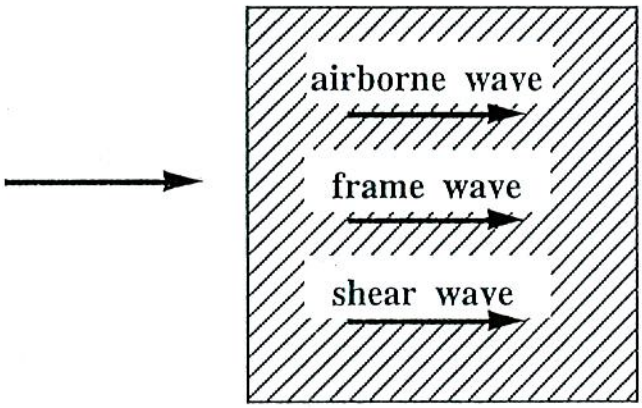
INTRODUCTION

- Foam FE modeling
  - effect of shape on absorption
  - effect of edge constraints on transmission
- Sound Transmission Treatments
  - previously layered
- Use FE Techniques to explore transmission loss potential
  - shaped systems
  - graded properties
  - mechanically resonant
  - implementaion of ART

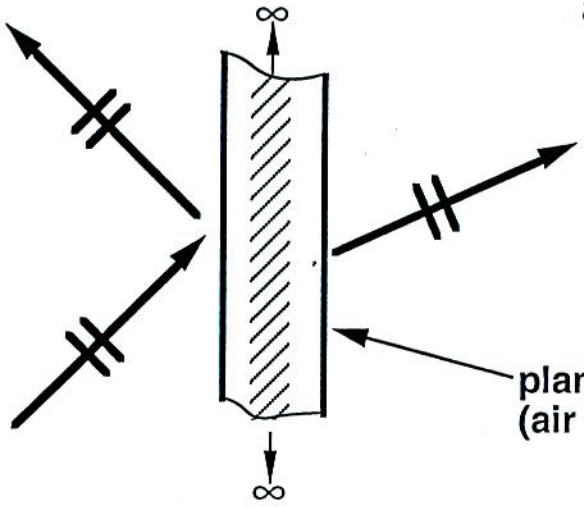
ELASTIC POROUS MATERIALS

- *Foam Material Properties*
  - Flow resistivity
  - Tortuosity (Structure Factor)
  - Porosity
  - Bulk Modulus of Elasticity
  - Poisson's Ratio
  - Loss Factor
- Biot Theory allows wave propagation to be expressed in terms of these macroscopically measurable properties.
- Multiple Wave Types → sensitive to boundary conditions

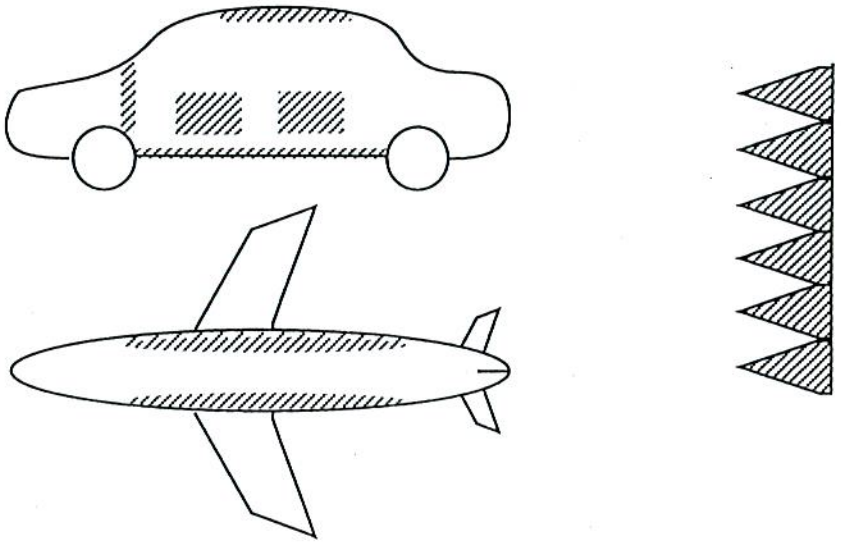


INTRODUCTION

- **Analytical Capabilities** — available by J.S. Bolton and J.F. Allard et al.

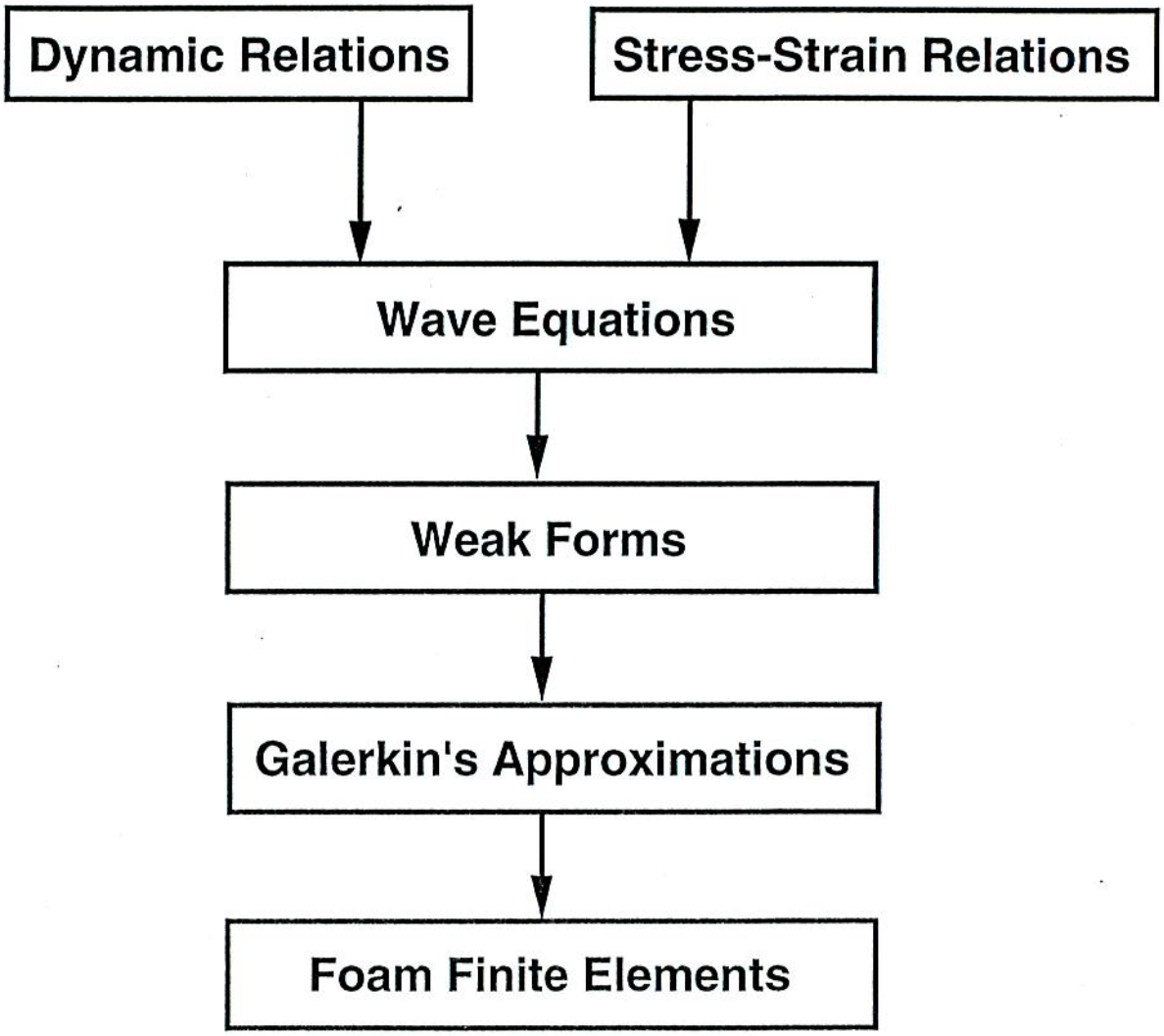


- **Practical Treatments**

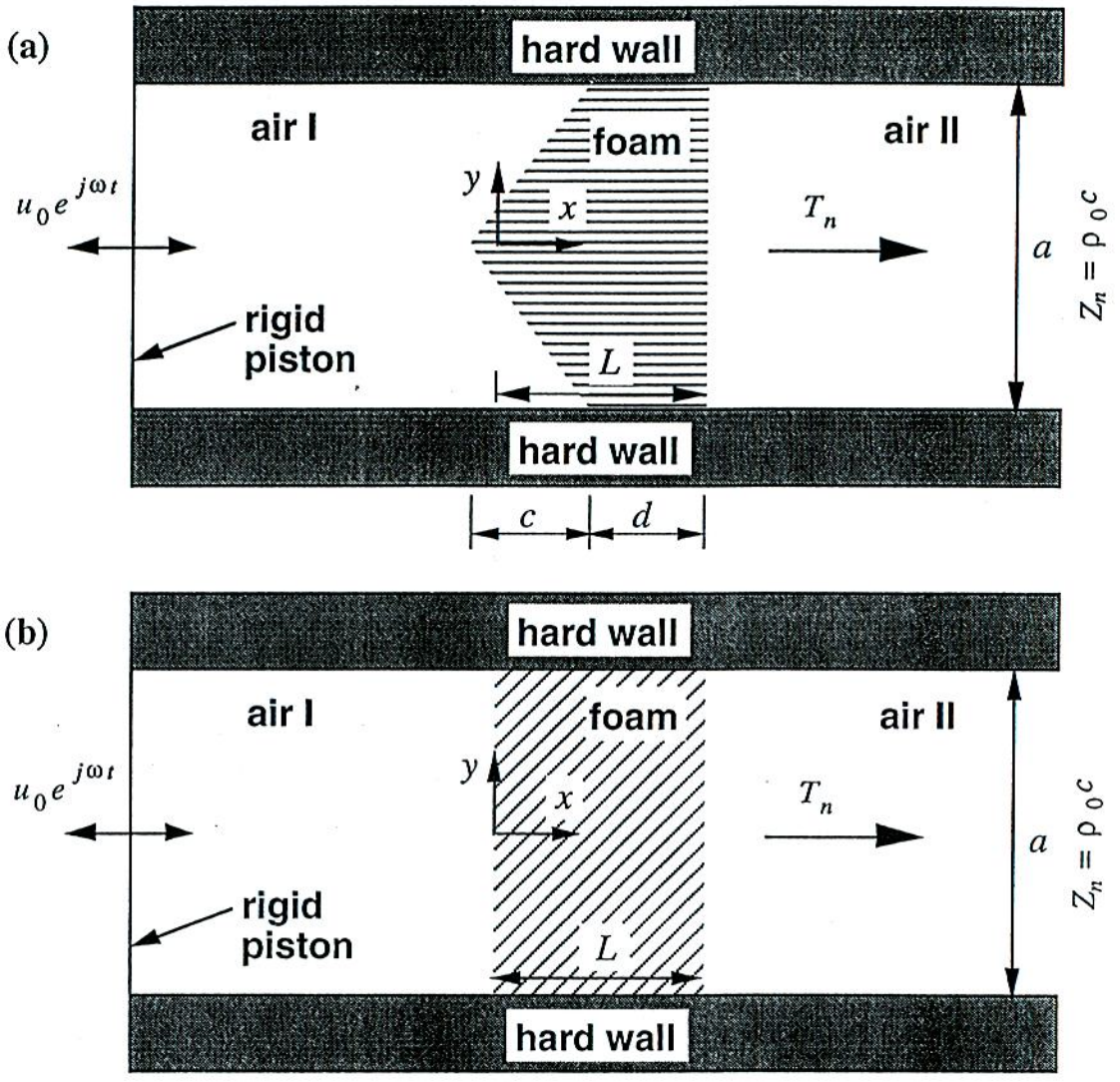


FOAM FINITE ELEMENTS

Elastic Porous Material Theory based on Biot

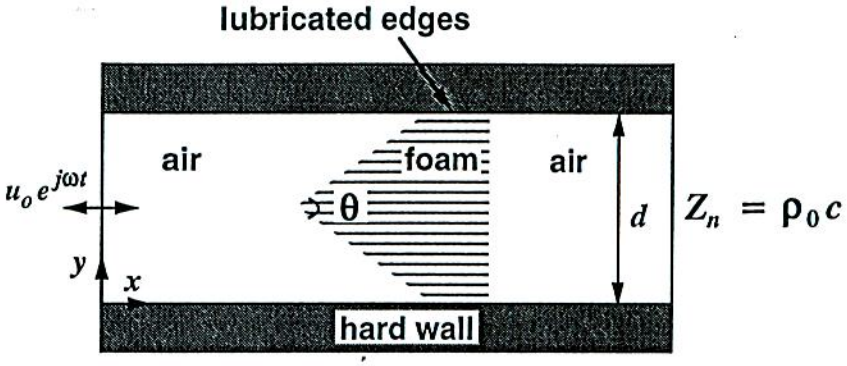


SYSTEM CONFIGURATIONS

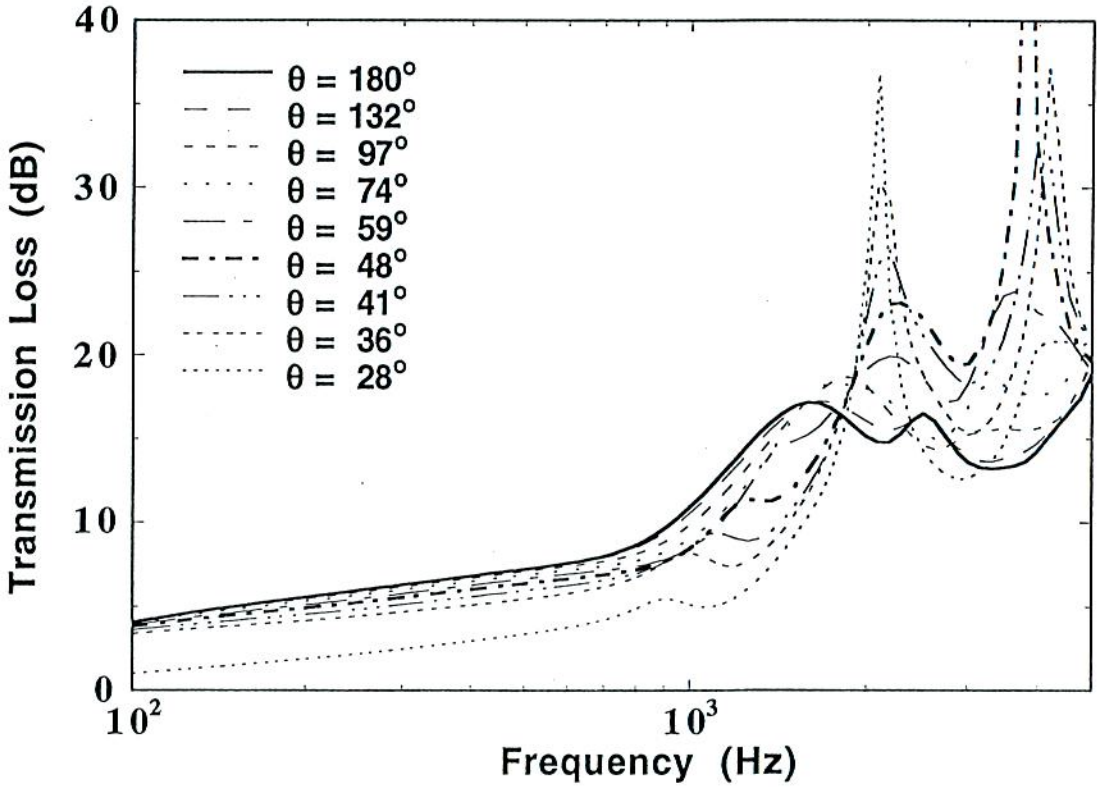


In system (b), tortuosity of a foam layer is varied spatially across the duct (in y-direction).

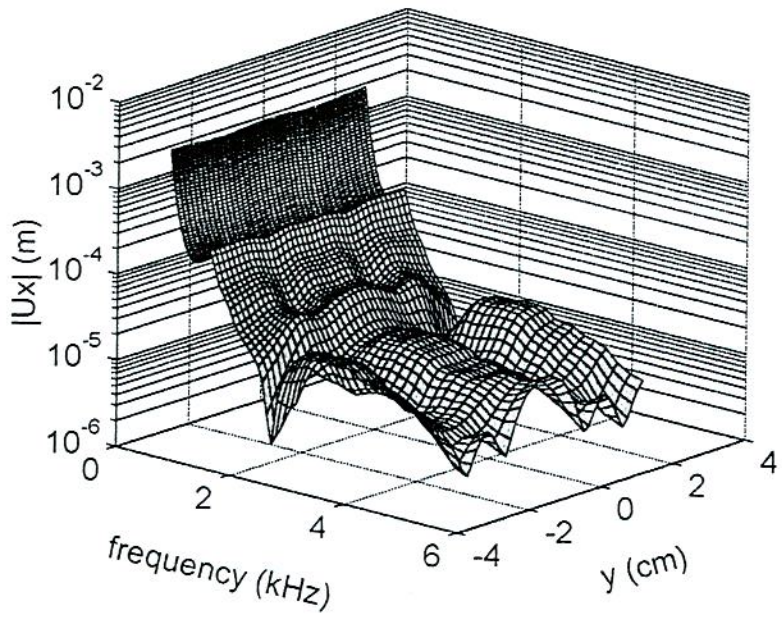
SOUND TRANSMISSION THROUGH A WEDGE

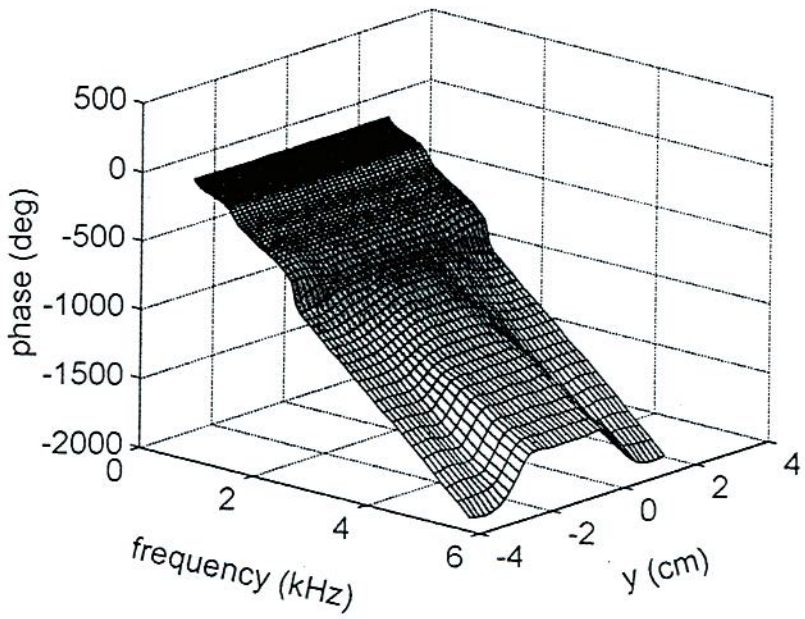


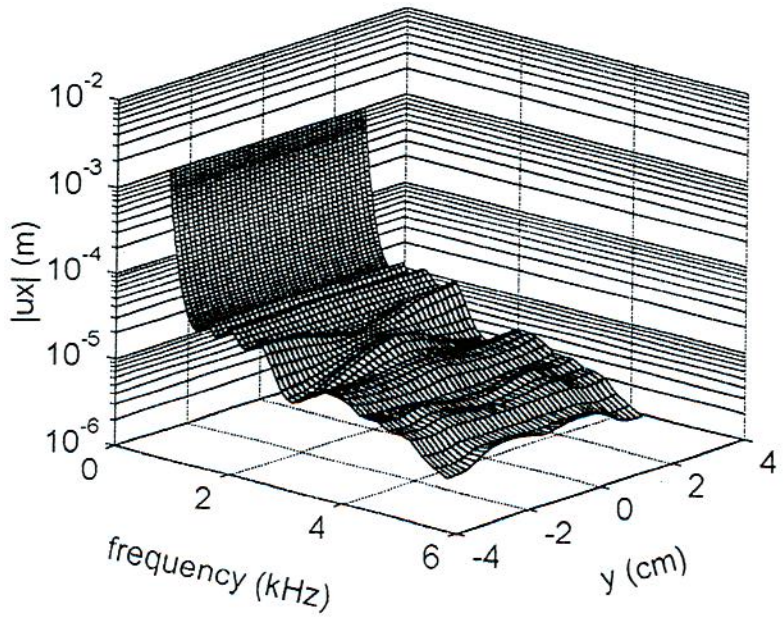
$d = 5.4$ cm

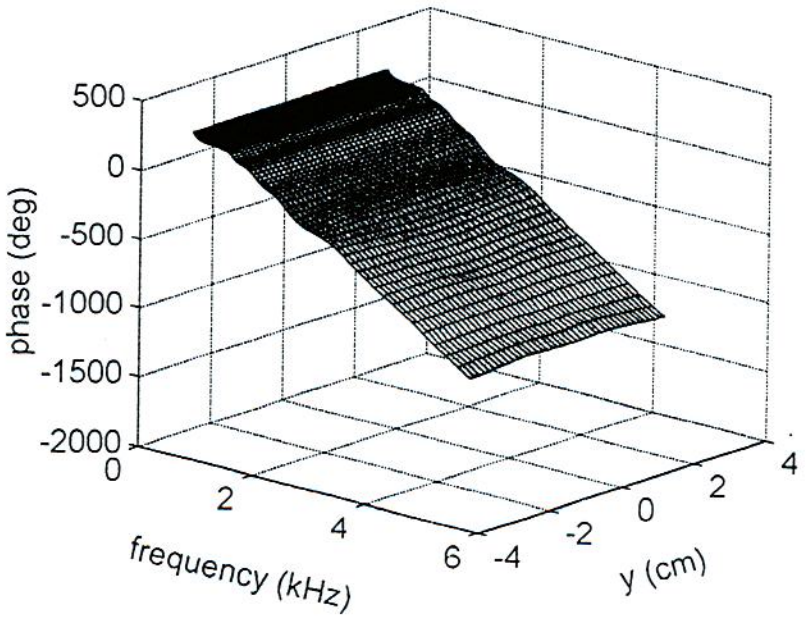


LUBRICATED FOAM WEDGE

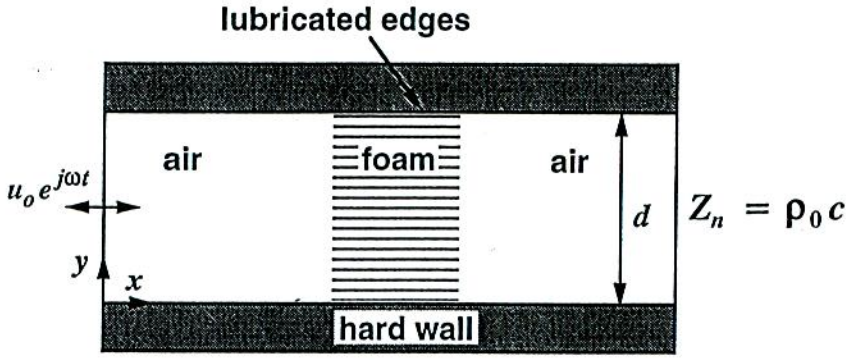




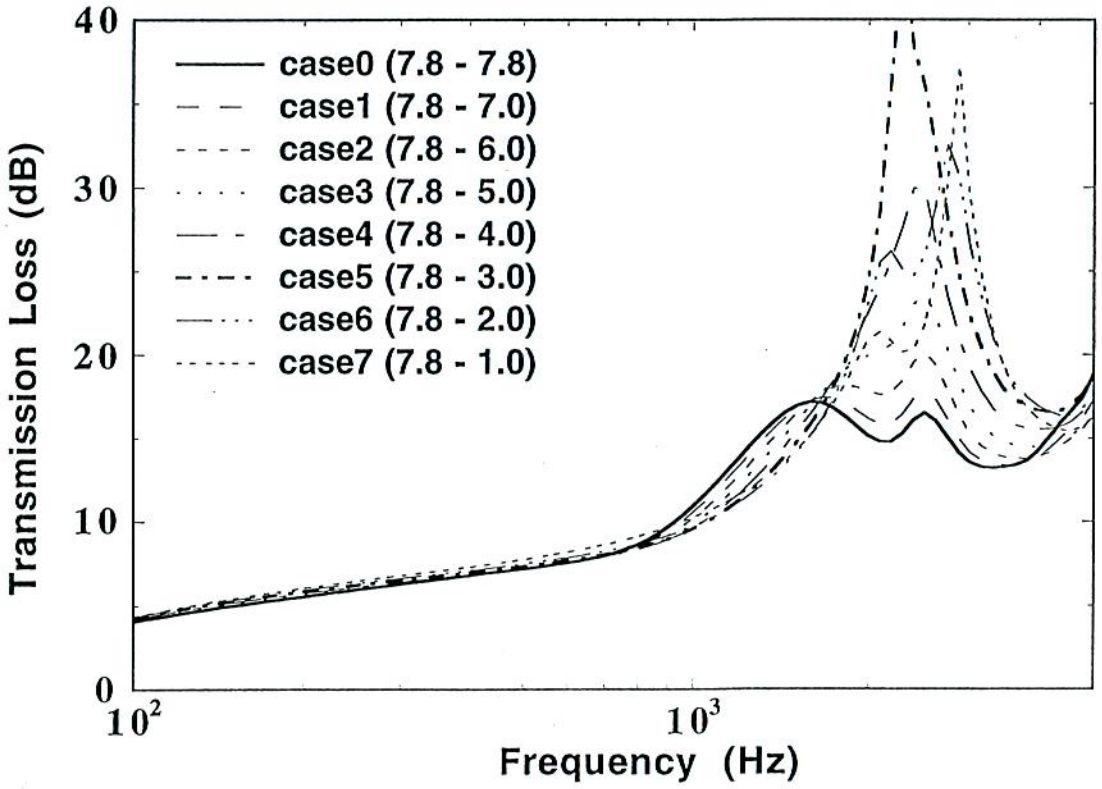




SOUND TRANSMISSION THROUGH A FOAM LAYER HAVING SPATIALLY GRADED TORTUOSITY

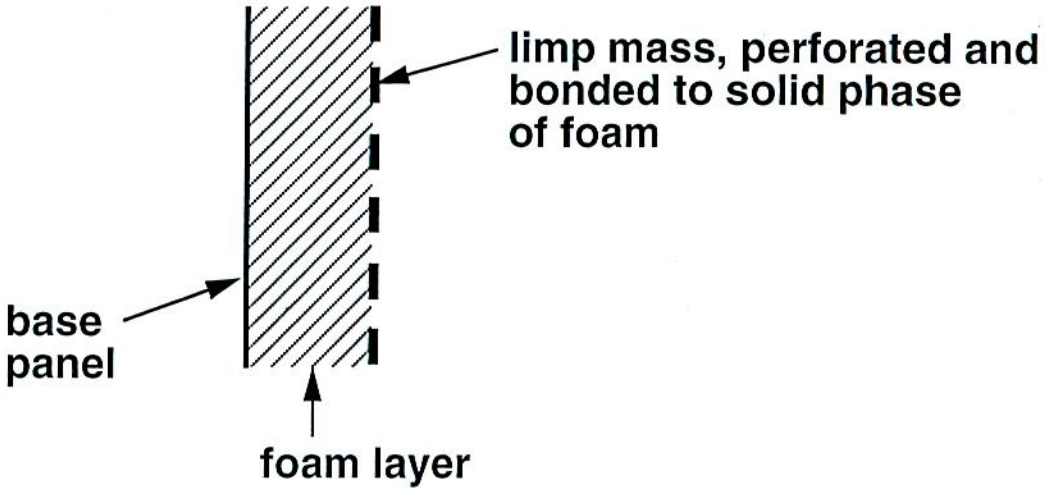


$d = 5.4$ cm

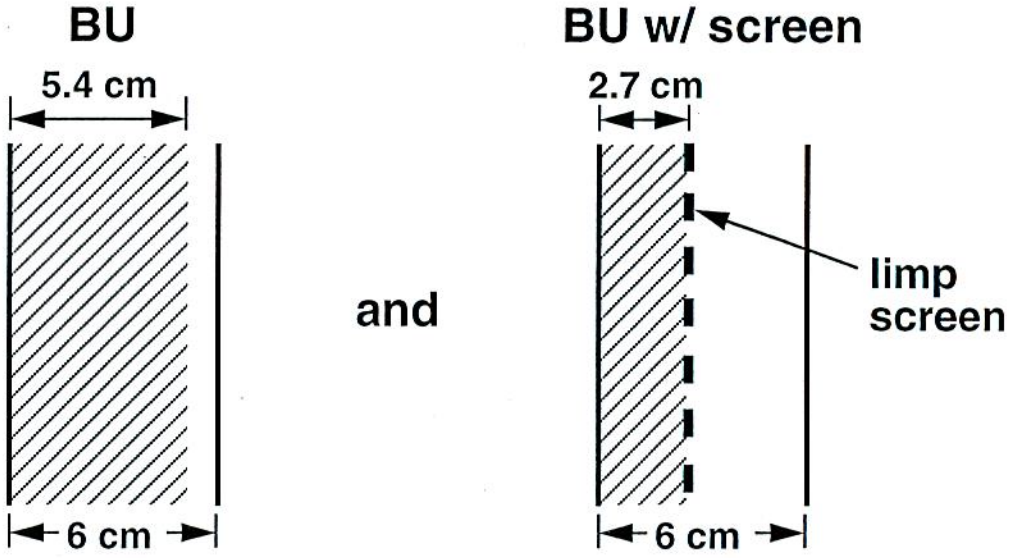


ALTERNATIVE TREATMENTS (1)

- To take advantage of resonance of solid phase



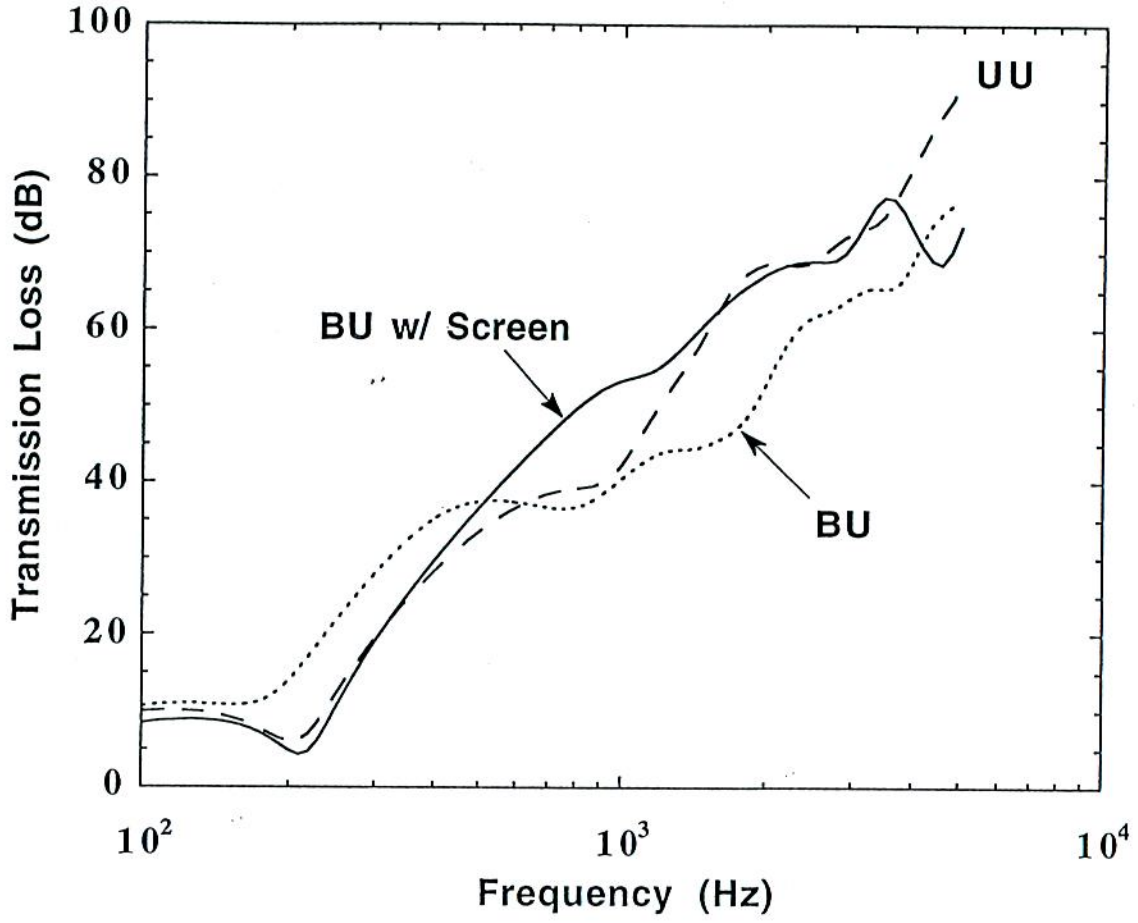
- Compare



— panels 0.030 in

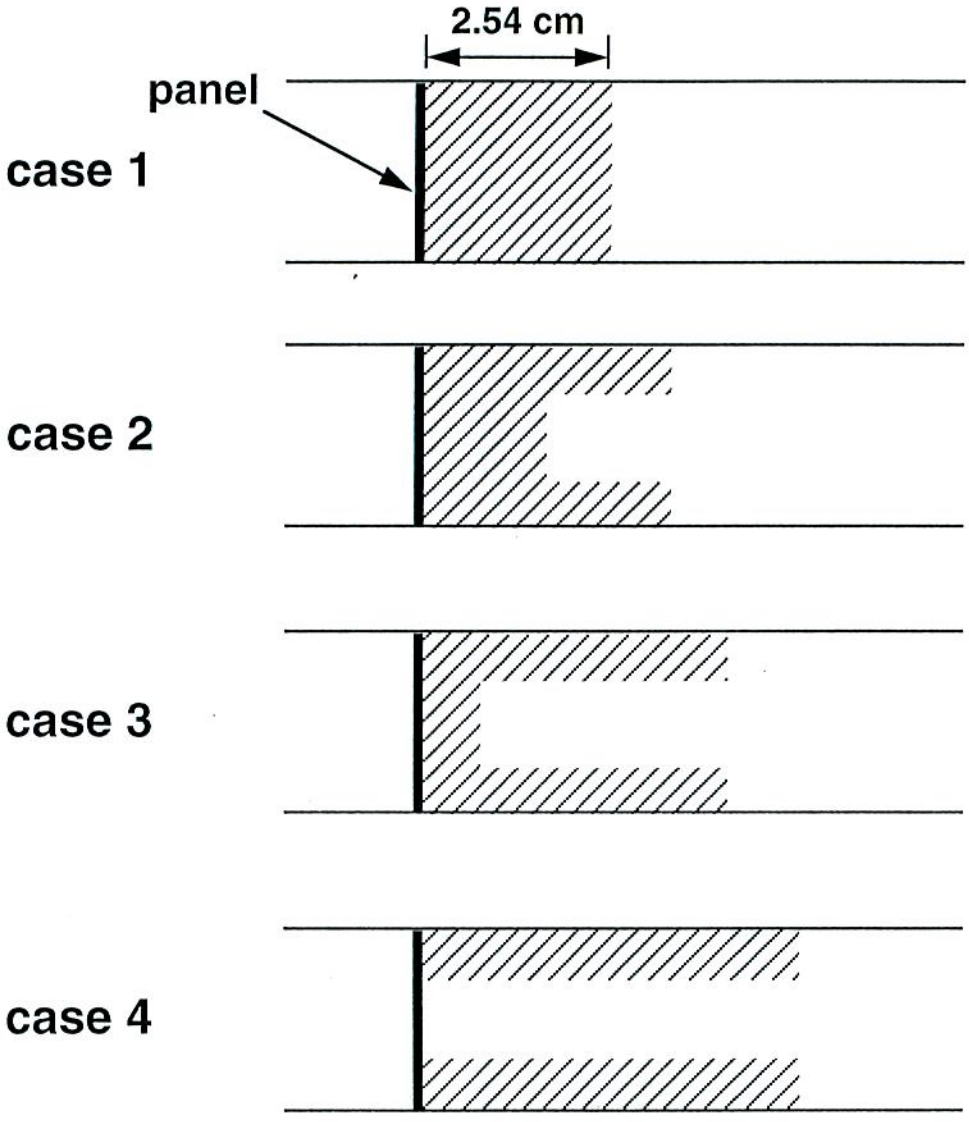
Note: Total mass/unit area the same.

ALTERNATIVE TREATMENTS (1)

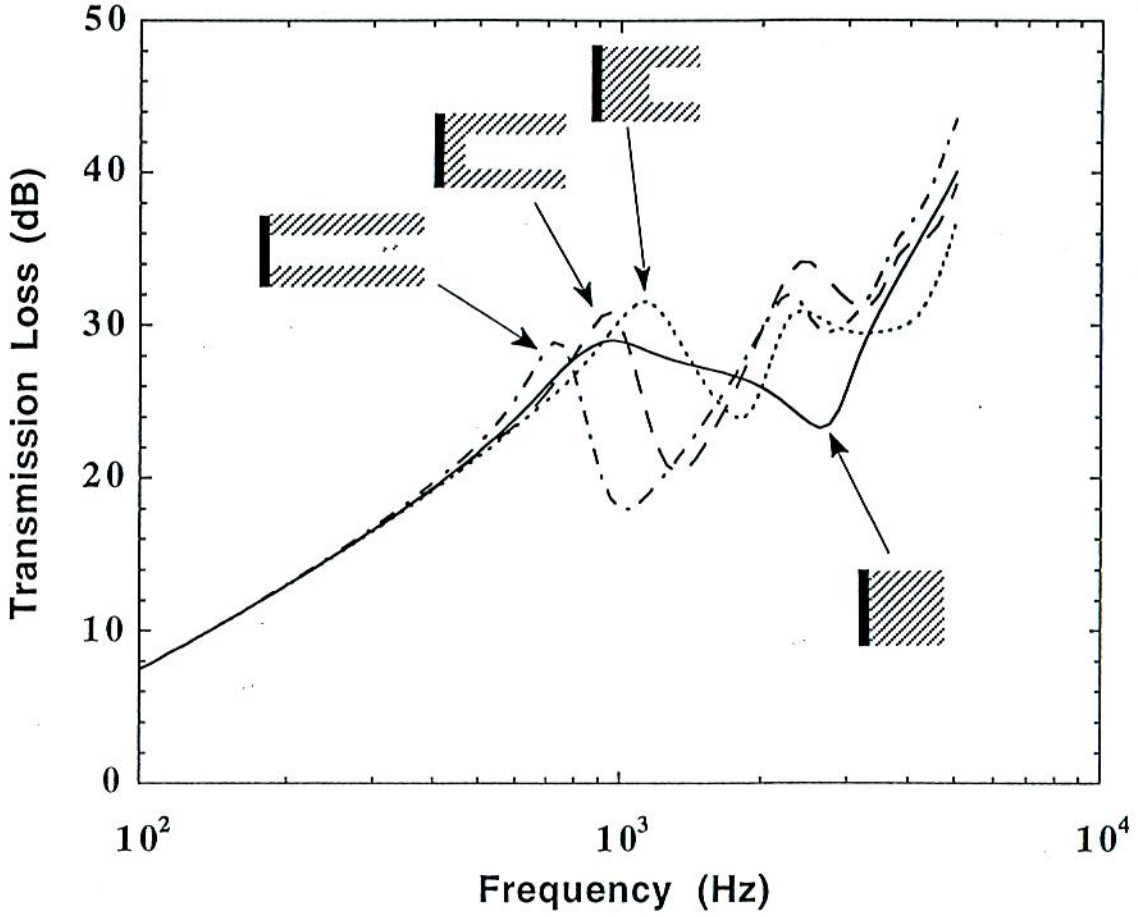


ALTERNATIVE TREATMENTS (2)

- Explore effect of shaping lining

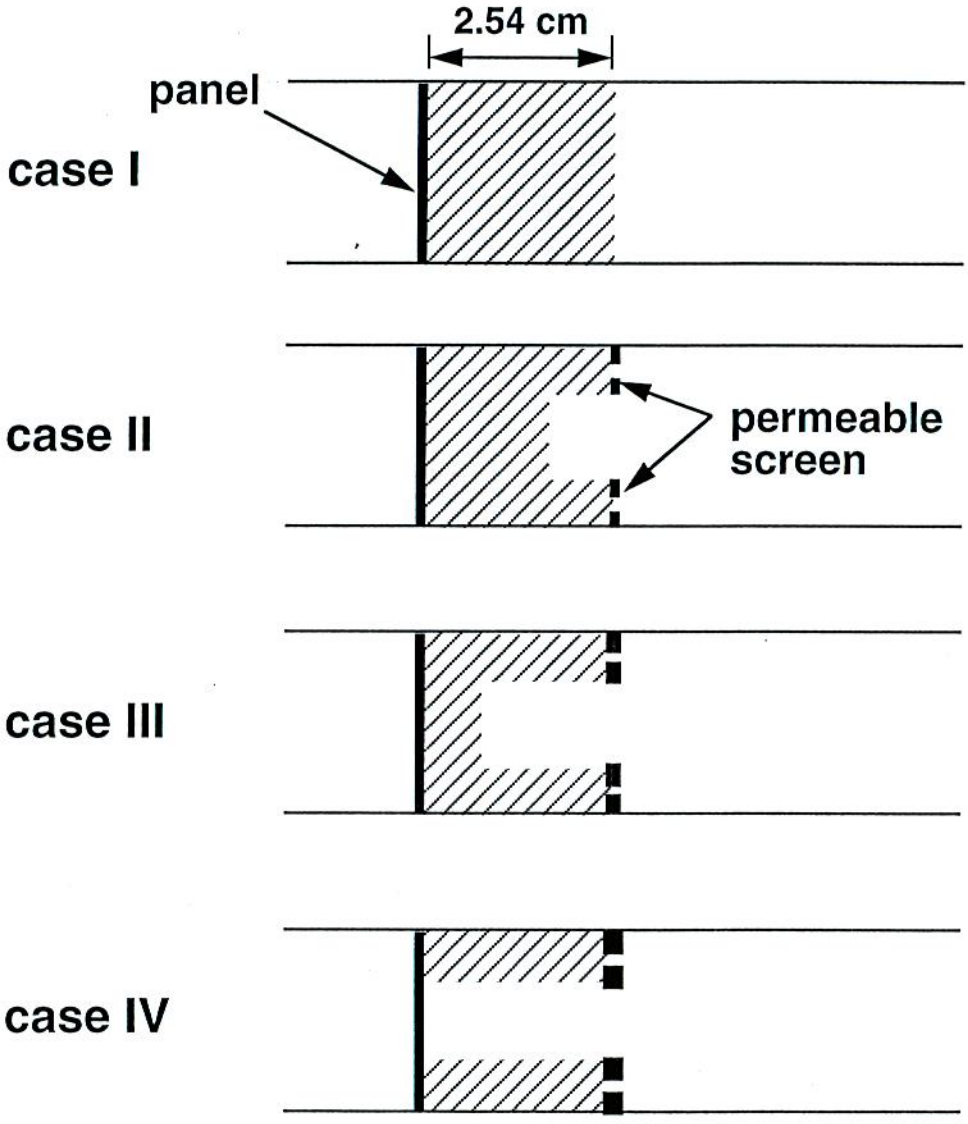


ALTERNATIVE TREATMENTS (2)

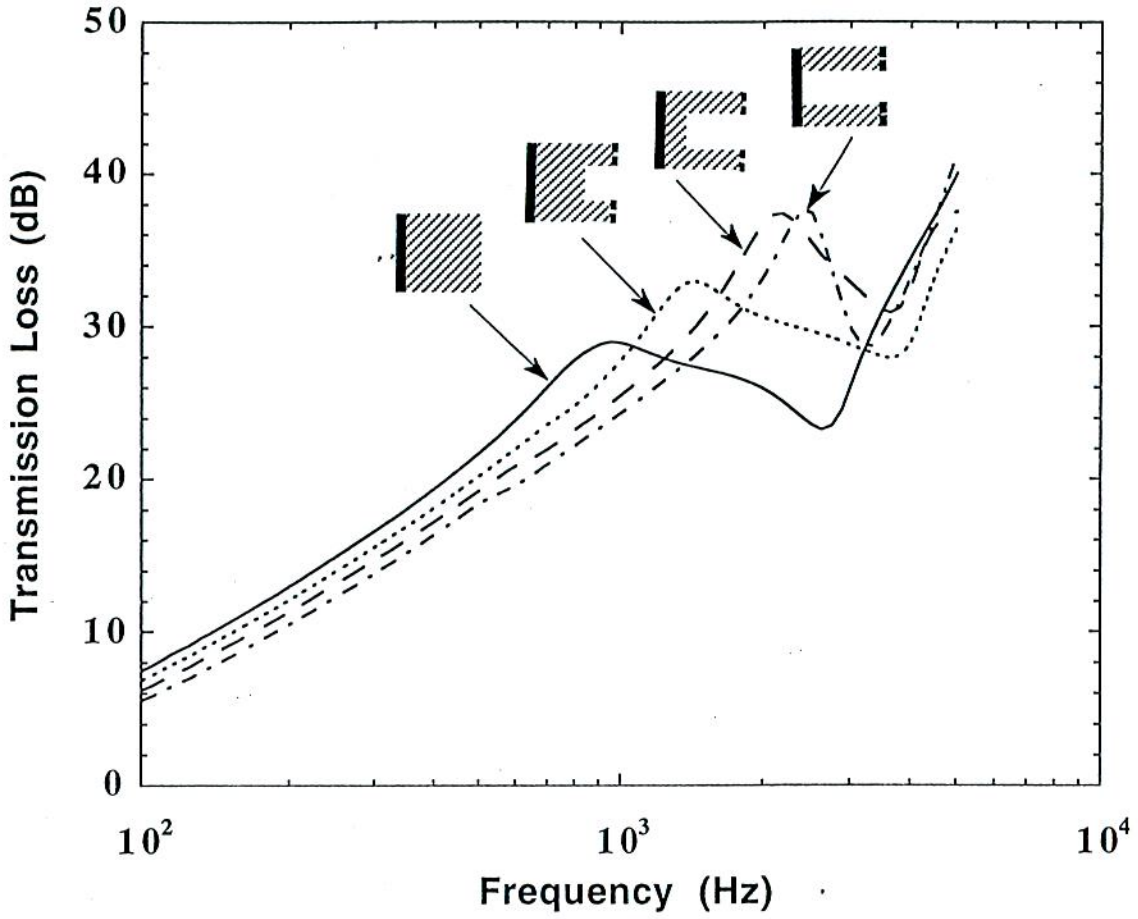


ALTERNATIVE TREATMENTS (3)

- Preserve depth, replace mass of foam with permeable, high porosity screen

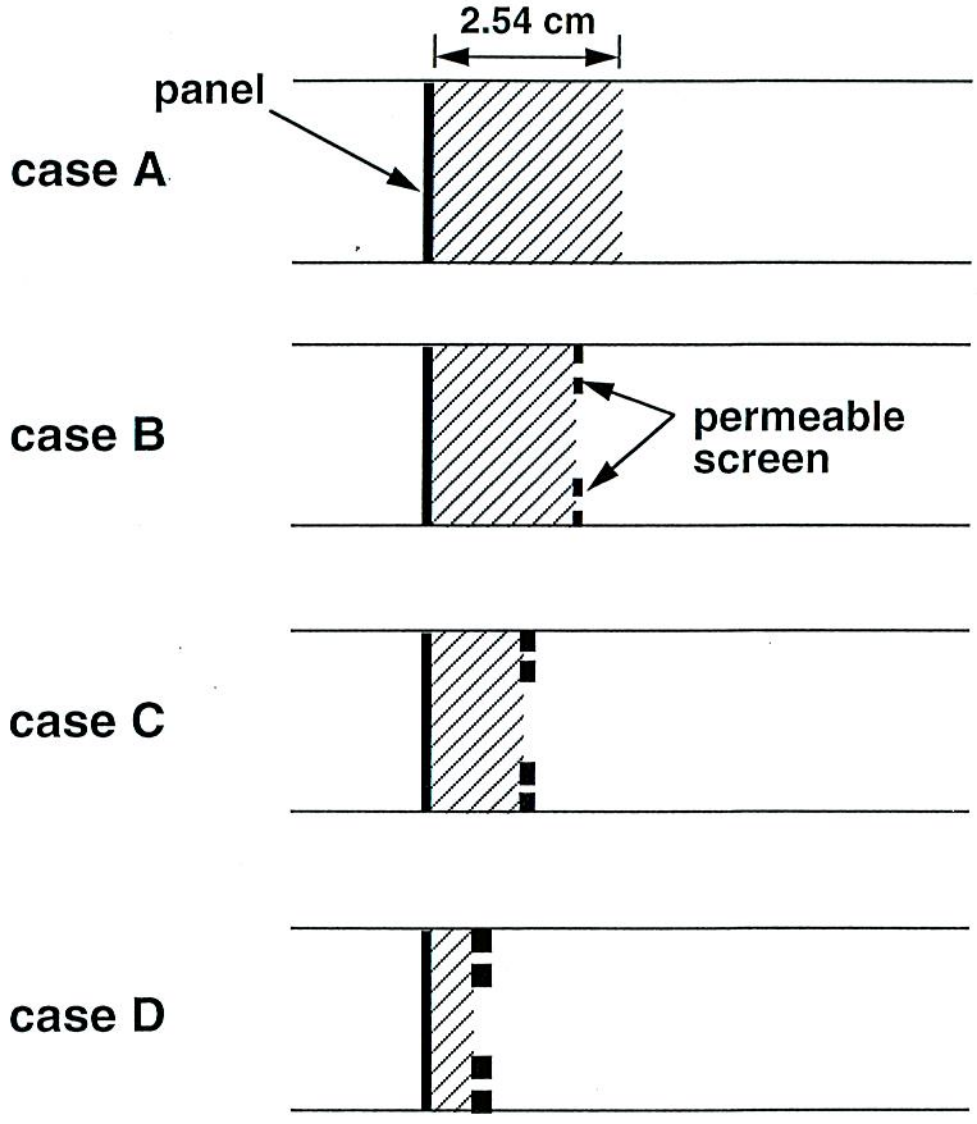


ALTERNATIVE TREATMENTS (3)

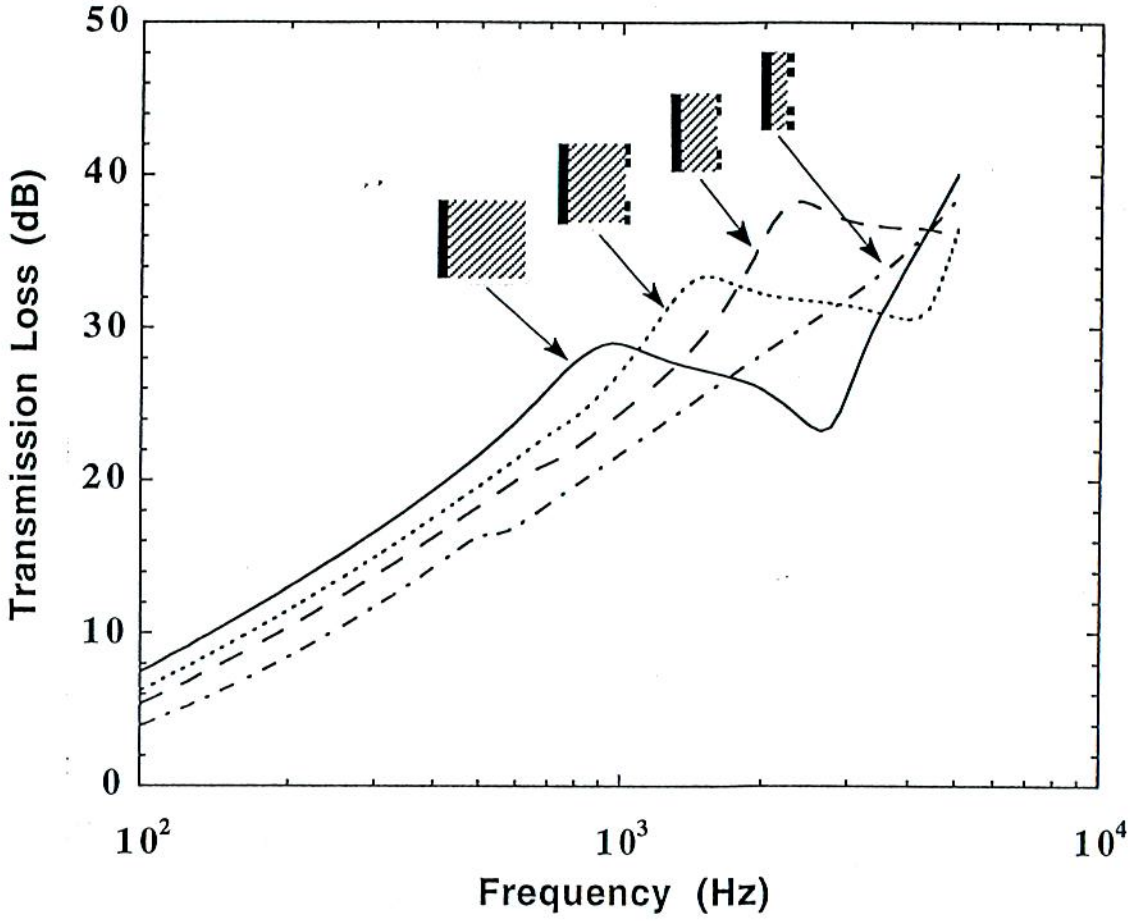


ALTERNATIVE TREATMENTS (4)

- Reduce total thickness and replace by permeable limp mass over part of the surface

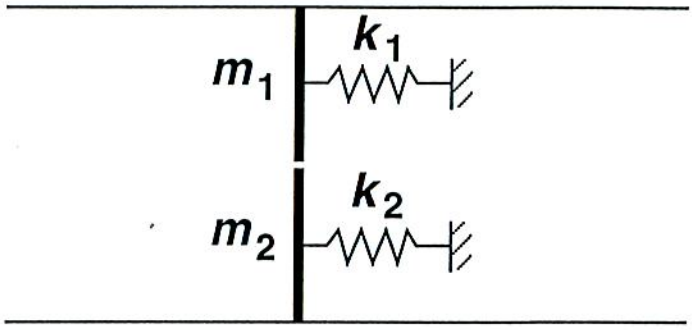


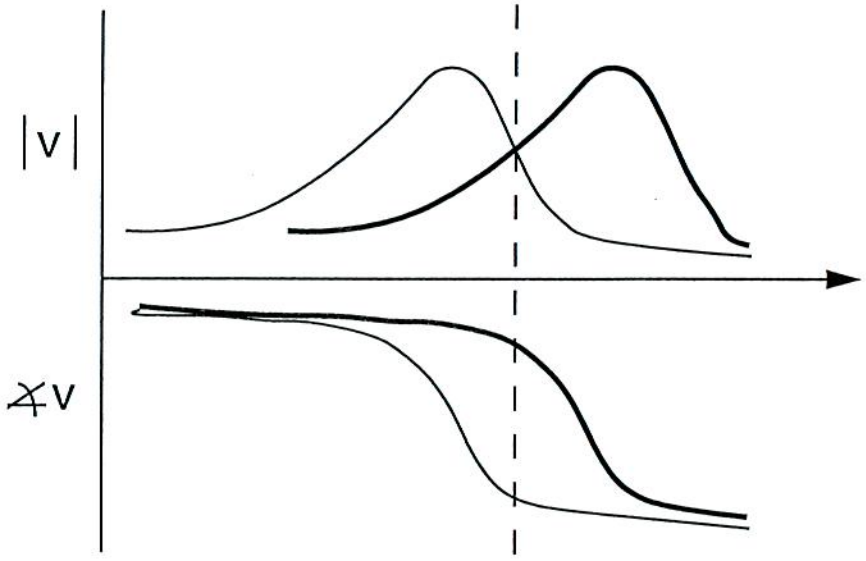
ALTERNATIVE TREATMENTS (4)



ALTERNATIVE TREATMENTS (5)

- Alternate Resonance Tuning

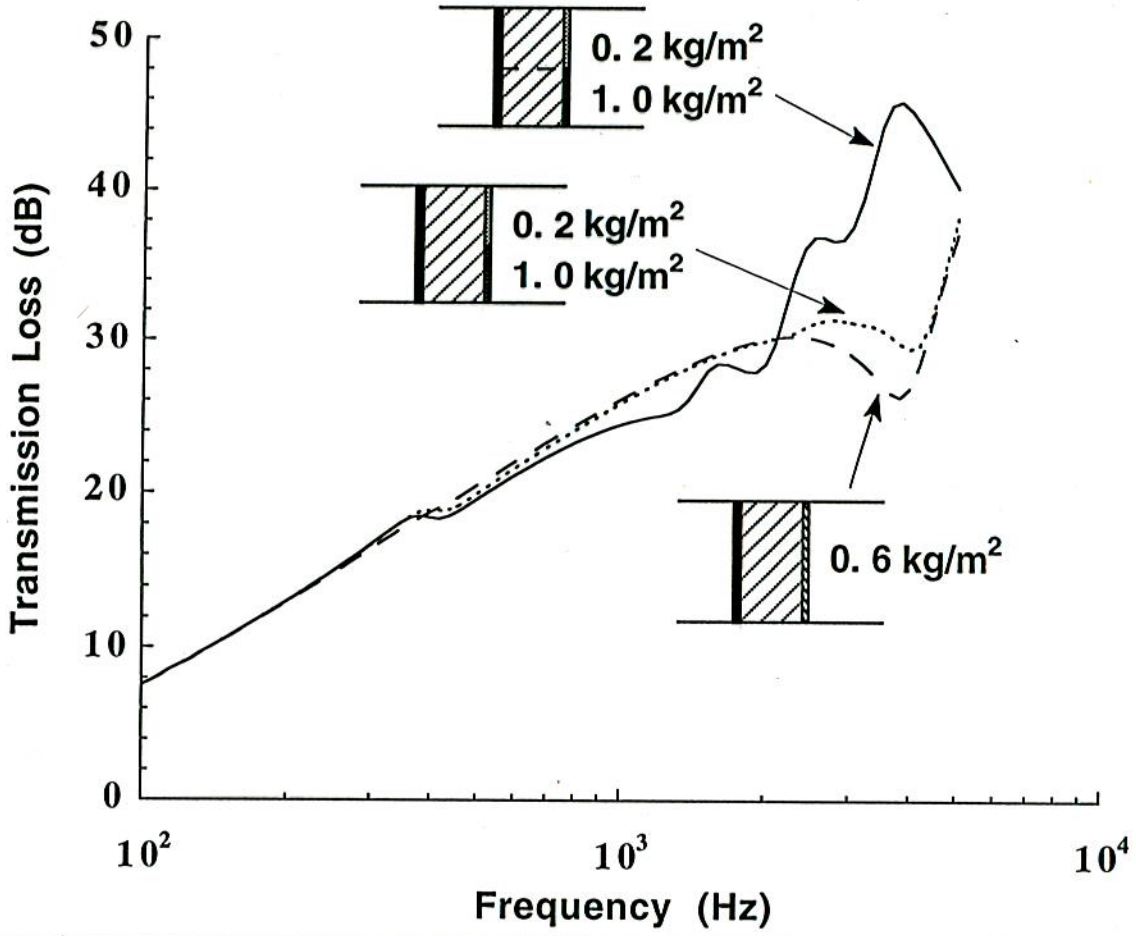




- Enhance TL at particular frequencies because of volume velocity cancellation.

ALTERNATIVE TREATMENTS (5)

- **Alternate Resonance Tuning**



CONCLUSIONS

- FEM can be used to perform detailed design studies of TL treatments.
- TL enhanced by "mode conversion" within treatments.
- Shaping lining and replacing foam with permeable or impermeable membranes improves performance in particular frequency ranges, usually at expense of low frequencies.
- Alternate Resonance Tuning Concept can be implemented using tuned foam elements.
- Promising treatments
  - permeable screen plus foam in double panel lining.
  - spatially graded foam properties.